EVALUATION OF PERSONAL CHEMICAL VAPOR PROTECTION FOR PATROL AND TACTICAL LAW ENFORCEMENT

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ABSTRACT

In Domestic Preparedness efforts, the US Army Soldier and Biological Chemical Command and the Maryland State Police, have evaluated personal chemical protective systems for use in patrol and tactical functions in law enforcement. Various Level C, impermeable and charcoal impregnated, vapor-absorptive, air-permeable protective clothing ensembles, worn with the MSA Millenium respiratory protective mask/butyl hood, and seven-mil butyl rubber gloves, have been considered. In cooperation with the Maryland State Police Special Tactical Assault Team Element (STATE), these ensembles were tested using the man-in-simulant test (MIST) processes. The test results have been used to indicate the chemical hazards that protective system users can be expected to encounter, should they operate in chemical warfare agent vapor contamination. This information is helping law enforcement personnel select personal chemical protective equipment and design chemical incident response plans that can successfully manage chemical warfare agent risks.

INTRODUCTION

The military community has dealt with the threat of chemical and biological warfare for over 86 years[1]. Now, the civil community faces that threat, through possible terrorist attacks involving chemical and biological warfare agents. Although such incidents are expected to remain less likely than many other civil emergencies, without preparation and awareness, the potential consequences of chemical or biological terrorism are significant.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **00 JAN 2002**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **Evaluation Of Personal Chemical Vapor Protection For Patrol And Tactical Law Enforcement**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army SBCCOM 5183 Blackhawk Road APG, MD 21010-5424; Maryland State Police 1201 Reisterstown Road Pikesville, MD 21208-3899**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
This article is from ADA409494 Proceedings of the 2001 ECBC Scientific Conference on Chemical and Biological Defense Research, 6-8 March , Marriott's Hunt Valley Inn, Hunt Valley, MD., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**7**	

The Maryland State Police (MSP) and the US Army Soldier and Biological Chemical Command (SBCCOM) are participating in the Domestic Preparedness program to help civilian communities prepare to deal with terrorism involving chemical and biological warfare agents. The Domestic Preparedness program provides civilian responders with the training and awareness that they need to develop safe and effective operational procedures for responding to such incidents.

To help civilian responders develop safe operational plans for response to terrorism involving chemical warfare agents (CWA), the MSP and the Improved Response Program have evaluated the hazards faced by personnel using various individual chemical protective ensembles, in various roles of law enforcement. By testing chemical protective ensembles in operational use scenarios, analyses have been performed to indicate approximate exposure times that will begin to result in chemical effect hazards to persons using the protective ensembles in CWA vapors. This information is being used to help responders select chemical protective systems and develop safe and effective operational procedures for the equipment's use.

PATROL AND TACTICAL LAW ENFORCEMENT ROLES

The local law enforcement community will perform many functions associated with a CWA terrorism incident. At the scene of a chemical terrorism incident, local law enforcement patrol officers may evacuate downwind hazard regions and maintain perimeter security. Perimeter security involves controlling traffic and controlling entry to, and exit from, the scene of the incident.

Law enforcement tactical teams, or SWAT teams, often perform high-risk entries. In tactical situations, the MSP employ the Special Tactical Assault Team Element (STATE). The MSP STATE team may perform hostage rescue, raid a suspected chemical terrorist facility, or apprehend a suspected chemical terrorist. Two principle modes of operation are employed. The stealth mode is used to close-in on perpetrators, without making the perpetrators aware of the team's presence. It involves quiet, slow, deliberate actions and may be a prolonged operation, lasting for many hours. The STATE also uses the dynamic mode, in which a site is quickly moved into and through, securing it in minutes. Dynamic operations are fast. They are performed quickly, before the perpetrators recognize the situation, or are able to respond.

In patrol and tactical operations, personnel may encounter CWA contamination. Different levels of CWA hazards are expected in different roles. In a chemical release, the security perimeter is normally placed a safe distance from the site of the release. However, changing meteorological conditions and uncertainty regarding the chemical release may result in vapor hazards at the perimeter. A perimeter security officer also may contact liquid contamination carried from the scene by a contaminated victim or perpetrator. The amount of contamination expected at the perimeter is small. Tactical missions may involve higher levels of chemical contamination. Chemical warfare agents, in the form of liquids, vapors and aerosols, may be encountered as a tactical team enters an area. A perpetrator may attack a tactical team with CWA or disseminate CWA in an attempt to prevent the tactical team from reaching their objective.

Individual chemical protective equipment will help reduce the hazards of CWA exposures that might occur in these operations. This work does not address law enforcement roles in HAZMAT operations. It is limited to assessing protective capability against chemical warfare agent (CWA) vapors that may be encountered by law enforcement personnel engaged in the perimeter patrol and tactical operations described.

CHEMICAL PROTECTIVE SYSTEMS

For the perimeter control mission, various impermeable, chemical-resistant, hooded, protective overgarment clothing systems (Level C[2]), were tested. All clothing systems were worn with the MSA Millenium Gas Mask/butyl hood, and seven-mil, butyl rubber gloves. In addition, the Maryland State Police Standard Duty Uniform was tested. The Maryland State Police Standard Duty Uniform also was worn under all Level C overgarments. The following clothing systems were tested for the perimeter control mission.

MSP Standard Duty Uniform
Tyvec ® Protective Wear ™ coverall
Dupont Tychem® 9400 suit
Kappler CPF®4 suit
Dupont Tychem® SL suit
Tyvek® Protech F suit

Figure 1. Donning personal protective system.

Figure 1 shows an MSP STATE officer donning a chemical protective suit in patrol tests. Details of each of these protective ensembles are available[3].

For tactical missions, the impermeable protective systems were found to create too much noise during movement. Air-permeable, charcoal-impregnated, military style, chemical protective systems appeared to be better suited for tactical missions. Tactical mission testing was performed with air-permeable, charcoal-impregnated, chemical protective overgarments and undergarments, including the following.

Hammer® Two-Piece Chemical Protective Overgarment
Saratoga® Chemical Protective Undergarment
Hammer® One-piece Chemical Protective Overgarment
Giat® SWAT One-piece Chemical Protective Overgarment
TOMPS® Two-Piece Chemical Protective Overgarment
LANX® Chemical Protective Undergarment

When the chemical protective overgarment included an integrated hood, the MSA Millenium mask hood was worn under the integrated hood, tucked fully beneath the overgarment. Chemical protective gloves were also worn, when supplied with the clothing ensemble. Details of these protective garments are available from their manufacturers.

Along with each of these protective systems, the MSP Special Tactical Assault Team Element (STATE) standard duty uniform, consisting of camouflaged fatigues and leather boots, was worn during each test. The MSP STATE team standard duty uniform was worn under the chemical protective overgarments and over the chemical protective undergarments.

OPERATIONAL TESTING PROCEDURES

The CWA protection offered by these chemical protective ensembles was measured using the Man-In-Simulant Test (MIST) procedure[4], at the Edgewood Area of Aberdeen Proving Ground. MIST fully assesses the protection offered by complete protective ensembles by measuring the absorption of chemical vapors at the surface of the skin, and compares that to the absorption that occurs at the skin without any protection. MIST is used by the US Army, in development of its personal chemical protective ensembles, and by the Domestic Preparedness program, in defining operational protective performance of personal protective systems[5].

MIST subjects wear full protective ensembles, in vapors, while performing activities that they would perform in an actual operation. MIST does not place people at risk of exposure to chemical agents because MIST uses a chemical simulant in place of chemical agent vapors. Standard fabric penetration measurements are used to identify simulants that penetrate protective systems at the same rates as chemical agent vapors. Such identified simulants are then be used to measure protective ensemble performance.

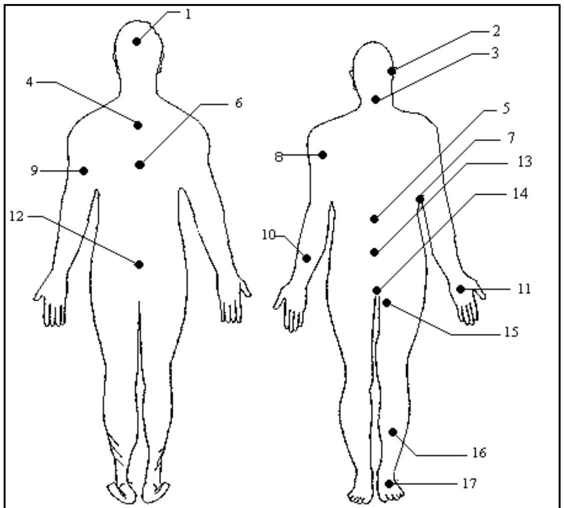

Figure 2. MIST sampler locations.

MIST uses passive samplers, which sample by absorption. These are placed on the skin, so they can accurately measure the absorption of the vapor at the skin surface. Sampler locations for these tests are illustrated in Figure 2. Figure 3 shows samplers being applied to MSP STATE team personnel before a test.


Figure 3. MIST samplers being placed on MSP STATE personnel.

During MIST, volunteers perform actions specific to their operation. Tests last for 30 minutes. Specific detailed actions have been defined for the patrol officer tests[6]. Tactical team chemical protection was measured with the full MSP STATE team as they performed mock raids at an SBCCOM warehouse building. The warehouse was sealed so that it could contain a stable vapor concentration. The interior of the warehouse was configured with moveable partitions. The physical layout was altered to present a variable floor lay-out to the MSP STATE team. Each MSP STATE team member performed their normal functions during the test. During the first 3 minutes of exposure, the STATE team used dynamic tactics to sweep through the warehouse test area. In the following 27 minutes, stealth tactics were used. The Figures 4-6, below , show STATE team personnel during tests.

After the 30 minute vapor exposure, protective clothing is removed. Vapor samplers are collected in a clean room. Analysis of each sampler yields the dosage received at the skin. The overall protective performance of the chemical protective system is determined by the Body Region Hazard Analysis[7].

Respiratory protective mask performance was not measured for this study. Mask performance is represented by the NIOSH nominal protection factor (PF) for negative pressure respirators; 50[8] and by a PF value that is easily achieved by modern negative pressure respirators, 6666[9].

Figure 4. Planning movement.

HAZARD ASSESSMENT ANALYSIS

Chemical hazards are determined by the chemical vapor concentration in the environment, the time spent in the concentration, the performance of the protective system, and the toxicity of the chemical agent vapor. By combining vapor concentration, protective system performance, and endpoint dosages for specified chemical agent effects, estimates of the exposure time required to reach the specified effect endpoint are obtained. Times required to reach specified effect endpoints are called stay times. At the stay time, exposures are not risk-free, but CWA effects are expected to be non-life-threatening.

Figure 5. Approaching the warehouse.

To determine stay times, values for endpoint dosages associated with chemical agent vapor effects, are taken from a recent review by elements of the National Research Council (NRC)[10].

Figure 6. Covering with shouldered weapons.

Stay times are assessed at three levels of chemical agent vapor concentration: perimeter, highly lethal, and saturation. The perimeter concentration corresponds to the maximum concentration expected at the down wind edge of the day-protect zone, as specified in the 2000 Emergency Response Guidebook[11], for a 55 gallon spill chemical agent. Details of dosage estimates for this situation are given by Stuempfle[12]. We refer to highly lethal concentrations as the concentration of chemical agent estimated to produce 95% lethality among unprotected persons exposed for 15 minutes. Lethal effect dosages recommended by the NRC are used to determine highly lethal concentrations. Worst-case vapor concentrations are referred to as saturation concentrations and are taken as saturation at a temperature of 18°C (65°F).

With agent concentrations; NRC-recommended threshold effects endpoint dosages; and protective ensemble performance, we have calculated stay times for various protective clothing ensembles and respiratory protection levels, for various threshold effects. Results are shown in Table 1.

TABLE 1. Minimum Stay Times (Minutes).

Respiratory Mask PF	Perimeter (Day Protect Zone) Concentration	Highly Lethal Concentration	Saturation (at 65°F) Concentration
50	850	3	0.007
6666	1500	20*	1

*For nerve agents, the minimum stay time for the highly lethal concentration is 400 minutes.

Table 1 provides worst-case (shortest) stay times for worst case chemical agents when wearing worst case clothes for perimeter concentrations. Table 1 values for highly lethal concentrations were also calculated using worst-case parameters, however, the stand-alone standard duty uniform was excluded as it provides minimal skin protection. With a PF of 50, the protective respirator is the limiting factor when determining stay times, because of threshold effects associated with the eyes. At saturated concentrations, stay times remain limited by threshold eye effects due to exposure to GB, for both values of respiratory PF. This is because GB has a much greater volatility that HD.

CONCLUSIONS

Chemical hazards involve many variables. By performing a quantitative hazard assessment, these many variables can be combined to yield specific results that provide useful information that will make a difference in field operations involving chemical hazards. By determining minimum stay times under a range of field conditions, useful guidance can be developed. The assessed stay times and the limiting variables lead us to the following guidance. This guidance does not consider operational hazards posed by contact with liquid agents. These remain to be addressed. Chemical protective gloves are recommended for the most likely scenarios where liquid chemical agents may be contacted.

- On the perimeter of a CWA terrorism incident, chemical protective clothing systems are of secondary importance to respiratory protection for vapor protection.
- The negative pressure respirator, with a respiratory PF of 50, will be the limiting factor in CWA operations and initial operations-degrading symptoms will be eye effects.
- The impermeable suits that were tested made too much noise for stealth operations.
- The charcoal protective suits that were tested should be considered applicable for escape purposes only, if a CWA should be released in interior spaces, during tactical operations.
- None of the tested ensembles are suitable for tactical/stealth operations in enclosed spaces where CWA have been released.

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